Relationship between the Duplex Doppler Ultrasound and a Questionnaire Screening for Positional Tolerance of the Cervical Spine in Subjects with Suspected Vascular Pathology: A Case Series Pilot Study

Eric G. Johnson, PT, DPTSc, NCS
Shaunna Houle, DPT
Andrea Perez, DPT
Summer San Lucas, DPT
Diane Papa, RVT

Abstract: Manual therapy healthcare practitioners routinely perform the vertebral artery test (VAT) to determine cervical positional tolerance and to screen for vertebrobasilar insufficiency (VBI) prior to manipulating the cervical spine. Because the safety and validity of the VAT has been questioned in the literature, the purpose of this study was to determine if a relationship existed between a new tool, the cervical positional tolerance questionnaire (CPTQ), and the duplex Doppler ultrasound findings for patients with suspected VBI. Subjects were 39 consecutive patients referred by their physician for a duplex Doppler ultrasound with suspicion of VBI. On the CPTQ, patients reported whether they avoided certain cervical positions due to symptoms consistent with VBI prior to undergoing the ultrasound. The CPTQ had a sensitivity = 1.00 (95% CI: 0.34–1.00); specificity = 0.78 (95% CI: 0.64–0.92); negative likelihood ratio = 0.00 (95% CI: 0.02–2.73); and positive likelihood ratio = 4.50 (95% CI: 1.67–7.89). The results of this case series study, while preliminary, are encouraging. Further research with larger sample sizes is warranted in the development of the CPTQ regarding pre-cervical manipulation clinical decision-making. Inclusion of subjects from a cohort including asymptomatic people (no suspicion of VBI) would also strengthen the screening ability of the CPTQ. In addition to duplex Doppler ultrasound, using a gold standard test of vertebral artery testing by way of magnetic resonance angiography (MRA) would further improve data on the diagnostic utility of the CPTQ.

Key Words: Vertebral Artery Test, Vertebrobasilar Insufficiency, Duplex Doppler Ultrasound, Manual Therapy

Forty-two percent of the population will experience dizziness at least once in their lifetime, and dizziness is among the 25 most common reasons Americans consult a physician[1]. Dizziness is caused by a variety of pathologies, including vertebrobasilar insufficiency (VBI)[2-8]. VBI is an occlusion of blood flow in the region where the vertebral and basilar arteries unite and is commonly associated with symptoms including dizziness, visual problems, drop attacks, incoordination, extremity weakness, headaches, hearing loss, loss of consciousness, arm or leg numbness, problems with speech, ringing in the ear, and acute anxiety or panic causing avoidance of certain head and neck positions[2-8].

Research suggests that blood flow to the contralateral vertebral artery is decreased when the cervical spine is rotated and extended to one side[9-13]. Licht et al[10] reported that during rotation, the contralateral vertebral artery slides forward and down, causing it to narrow because it is fixed in the

Address all correspondence and requests for reprints to:
Eric G. Johnson
Loma Linda University
Department of Physical Therapy
School of Allied Health Professions
Nichol Hall Office #1900
Loma Linda, CA 92350
E-mail: ejohnson@llu.edu.

surrounding structures. Collateral circulation in the brain, the Circle of Willis, connects each internal carotid artery to the basilar artery by way of the posterior communicating artery and connects the anterior cerebral arteries by way of the anterior communicating artery[14]. Rivett et al[15] suggested that collateral vascular supply is sufficient to prevent symptoms of VBI in normal individuals. A number of healthcare professionals including physical therapists, chiropractors, and osteopaths routinely perform the vertebral artery test (VAT) on patients to determine tolerance to cervical extension and rotation prior to manipulation or to differentiate between dizziness caused by VBI from dizziness caused by other conditions, such as benign paroxysmal positional vertigo (BPPV), an inner ear pathology[3,6,16-17]. The VAT movements of coupled rotation and extension of the cervical spine can affect blood flow velocities through the vertebral artery[3]. In individuals with vascular disease, the cerebrovascular collateral circulation may be compromised to the extent that compression of the vertebral arteries could lead to VBI and result in negative consequences, such as a stroke[12,16,18]. Furman and Whitney[18] noted, "Whether extension and rotation of the neck should or should not be performed in an attempt to diagnose VBI is controversial. Such maneuvers may reduce blood flow in the vertebrobasilar circulation and lead to an infarction." Di Fabio[17] reported that the sustained posture required for the VAT exposes the patient to greater risk than manipulation. Additionally, studies have shown a high likelihood of obtaining false negative results when performing the VAT, suggesting that the validity of the VAT is poor[19-22].

The duplex Doppler ultrasound, a non-invasive ultrasonic procedure, is commonly used to determine whether blood flow through the vertebral and carotid arteries is compromised[11-13, 23]. Research has suggested that the duplex Doppler ultrasound is a safe, non-invasive, painless, cost-effective, widely available, and easily administered diagnostic test[2-3,11-12,23]. The duplex Doppler ultrasound gives an accurate measure of blood flow in real time, allowing for the flow of blood to be measured at various points within an artery[9,12,23]. Although there are several tests for vertebral artery occlusion, such as the magnetic resonance angiography (MRA), computerized axial tomography (CAT) scan, and arteriography, the duplex Doppler ultrasound appears to be the most widely used due to its accessibility and cost-effectiveness for patients and health providers[2-3, 11-12, 23]. However, Rivett et al[15] did raise a good point: The Doppler Duplex ultrasound is not a practical option in most manual therapy clinics. They proposed the velocimeter as a possible alternative.

In the present investigation, we developed a screening tool called the cervical positional tolerance questionnaire (CPTQ), which is used to screen a patient's positional tolerance of the cervical spine. A literature search using Medline, PubMed, and Cinahl found no studies correlating the duplex Doppler ultrasound and a cervical position tolerance questionnaire. Therefore, the purpose of this study was to determine if there was a relationship between the CPTQ and the duplex Doppler ultrasound in subjects referred by their physician with suspected VBI.

Methods

Subjects

Thirty-nine consecutive subjects (22 females and 17 males) between the ages of 39 and 89 years (mean=67.7, SD=12.8) participated in this study. All subjects were referred by their physician with suspicion of VBI for duplex Doppler ultrasound at the Radiology Department of Loma Linda University Medical Center in Loma Linda, CA. All subjects signed the California Experimental Subject's Bill of Rights form and signed an informed consent document approved by the Loma Linda University Adventist Health Sciences Center Institutional Review Board prior to participation in the study.

Equipment

The duplex Doppler ultrasound used in this study was an Advanced Technology Laboratories HDI 3000 system (HDI 3000, Advanced Technology Laboratories, Bothell, WA, USA). This unit performed transcranial insonation of the vessels using a Linear 7.4 MHz transducer. The common, external, and internal carotid arteries as well as the vertebral arteries were evaluated with gray scale imaging and pulsed Doppler spectral analysis. A certified ultrasonographer set the parameters of the system and performed all duplex Doppler ultrasound measurements.

Procedures

The researchers administered the CPTQ to all subjects prior to having their ultrasound. The CPTQ contains questions relative to avoiding certain neck positions because of provocation of symptoms consistent with VBI (Table 1). If subjects answered "Yes" or "Sometimes" to any of the questions, the CPTQ was considered positive. A certified ultrasonographer, who was blind to the results of the CPTQ, then performed the ultrasound measurements in a quiet warm well-lit room. The ultrasonographer asked subjects to lie supine on a treatment table. A warm conductive gel was applied bilaterally to the neck overlying the carotid and vertebral arteries. Subjects experienced no pain and only mild pressure from the ultrasound transducer. Sound waves were emitted from the Linear 7.4 MHz transducer, resonating off the arterial wall and back to the transducer, which converted these echoes to electronic signals shown on a monitor. During the examination, the ultrasonographer identified each subject's vertebral artery blood flow as either normal or abnormal. The left and

TABLE 1. Cervical Positional Tolerance Questionnaire (CPTQ).

Cervical Positional Tolerance Questionnaire (CPTQ)

Instructions: Questionnaire is administered by the clinician. The clinician begins by reading question #1 in the left-hand column to the patient. The clinician then reads each of the symptoms in the right-hand column and the patient is instructed to answer Yes, No, or Sometimes for each symptom. The clinician then proceeds to question 2 and 3 in the same manner.

1. Do you avoid looking up as if into a high cabinet shelf because doing so causes:	■ Visual Problems or Dizziness	YES / NO / SOMETIMES
	■ Sudden Drop to the Floor	YES / NO / SOMETIMES
	■ Unsteadiness	YES / NO / SOMETIMES
	■ Extremity Weakness	YES / NO / SOMETIMES
	■ Confusion	YES / NO / SOMETIMES
	■ Headaches	YES / NO / SOMETIMES
	■ Hearing Loss	YES / NO / SOMETIMES
	■ Loss of Consciousness	YES / NO / SOMETIMES
	■ Arm or Leg Numbness	YES / NO / SOMETIMES
	■ Problems with Speech	YES / NO / SOMETIMES
	■ Ringing in the Ear	YES / NO / SOMETIMES
	■ Numbness around Mouth	YES / NO / SOMETIMES
2. Do you avoid looking over your left shoulder as if backing up your car because doing so causes:	■ Visual Problems or Dizziness	YES / NO / SOMETIMES
	■ Sudden Drop to the Floor	YES / NO / SOMETIMES
	■ Unsteadiness	YES / NO / SOMETIMES
	■ Extremity Weakness	YES / NO / SOMETIMES
	■ Confusion	YES / NO / SOMETIMES
	■ Headaches	YES / NO / SOMETIMES
	■ Hearing Loss	YES / NO / SOMETIMES
	■ Loss of Consciousness	YES / NO / SOMETIMES
	■ Arm or Leg Numbness	YES / NO / SOMETIMES
	■ Problems with Speech	YES / NO / SOMETIMES
	■ Ringing in the Ear	YES / NO / SOMETIMES
	■ Numbness around Mouth	YES / NO / SOMETIMES
3. Do you avoid looking over your right shoulder as if backing up your car because doing so causes:	■ Visual Problems or Dizziness	YES / NO / SOMETIMES
	■ Sudden Drop to the Floor	YES / NO / SOMETIMES
	■ Unsteadiness	YES / NO / SOMETIMES
	■ Extremity Weakness	YES / NO / SOMETIMES
	■ Confusion	YES / NO / SOMETIMES
	■ Headaches	YES / NO / SOMETIMES
	■ Hearing Loss	YES / NO / SOMETIMES
	■ Loss of Consciousness	YES / NO / SOMETIMES
	■ Arm or Leg Numbness	YES / NO / SOMETIMES
	■ Problems with Speech	YES / NO / SOMETIMES
	■ Ringing in the Ear	YES / NO / SOMETIMES
	■ Numbness around Mouth	YES / NO / SOMETIMES

SCORE = _____ (Total # YES Responses + Total # SOMETIMES Responses). Scores $\geq$ 1 constitute a positive CPTQ.

right vertebral arteries in all subjects were tested in neutral, right, and left cervical rotation. The duplex Doppler ultrasound took approximately 30 minutes to complete.

Data Analysis

A typical 2 X 2 matrix (true positives in the top left corner and true negatives in the bottom right corner) was used, and data analysis included sensitivity, specificity, prevalence, and likelihood ratios with their corresponding 95% confidence intervals.

Results

The CPTQ and duplex Doppler ultrasound results are listed in Table 2. Prevalence of a positive duplex Doppler ultrasound was 0.077 (3 abnormal ultrasound results). Because 1 of the 3 subjects with an abnormal ultrasound result reported that he "did not recall" if he avoided certain positions of the cervical spine, we made the decision to exclude him from our data analysis. This reduced our total number of subjects to 38 and our prevalence to 0.053. Of the remaining 38 subjects, the CPTQ had a sensitivity = 1.00 (95% CI: 0.34–1.00); specificity = 0.78 (95% CI: 0.64–0.92); negative likelihood ratio = 0.00 (95% CI: 0.02–2.73); and a positive likelihood ratio = 4.50 (95% CI: 1.67–7.89).

Discussion

The Guide to Physical Therapist Practice[24] encourages clinicians to use valid and reliable tests and measures. In the case of clinically available screening tests for VBI, reliable and valid tests and measures to sufficiently guide the clinical decision-making process do not currently exist[19]. Childs et al[19] reported that physical therapists are currently unable to confidently rule out the possibility for VBI because there is not sufficient evidence to support current screening tests and measures. DiFabio[17] reported that there is no compelling evidence that supports the use of symptom provocation testing as valid clinical screening tools to rule out vertebrobasilar insufficiency prior to manipulation of the cervical spine. Greenman[5] stated, "Probably the best sign of impeding cerebral anoxia is the symptom of acute anxiety and panic."

TABLE 2. Results of the Cervical Positional Tolerance Questionnaire (CPTQ) and the Duplex Doppler Ultrasound.

	Duplex Doppler Ultrasound: Positive	Duplex Doppler Ultrasound: Negative	Total
CPTQ: Positive	2	8	10
CPTQ: Negative	0	28	28
Total	2	36	38

The results of the present investigation demonstrated that the CPTQ has excellent sensitivity (1.00) and good specificity (0.78) when compared to duplex Doppler ultrasound. While further investigation is certainly necessary, the results of this pilot study are a promising step forward in improving the decision-making process with regards to pre-manipulative cervical spine screening.

The Guide to Physical Therapist Practice[24] also states that using tests and measures lacking established validity and reliability might be appropriate if there is not an available alternative. The VAT certainly fits this description and is commonly used in clinical practice as a screening test for VBI despite controversy surrounding this test[25-26]. Cote et al[20] measured vascular impedance on 42 subjects with Doppler ultrasonography while in the VAT position and determined the sensitivity and positive predictive values of the VAT to be zero. Terenzi[27] reported a case in which a 28-year-old female complained of symptoms consistent with VBI. Although the VAT was negative, transcranial Doppler and MRA imaging detected vascular patency deficits. In this case report, the results of the VAT were described as a false negative.

Despite the controversy surrounding the VAT, many clinicians continue to use it as part of their initial examination. Asavasopon et al[25] reported that patient symptoms consistent with VBI were produced while performing the VAT and the patient was referred for further diagnostic imaging. Results from both ultrasonography and MRA confirmed 80% to 90% stenosis in the left internal carotid artery and the patient subsequently underwent an endarterectomy.

Limitations

A major limitation of this study was that it was grossly underpowered, as only 3 subjects had a positive duplex Doppler ultrasound. Given the low prevalence, future research will need to include a substantially larger sample size in order confirm the sensitivity, specificity, and positive and negative likelihood ratios of the CPTQ. The design of the study was to include consecutive patients referred to radiology by their physician with suspicion of VBI. Given the low number of

true positives, despite a referral from a physician suspecting VBI, it appears that the incidence of true VBI is low. Future studies with substantially larger sample sizes are necessary to capture greater numbers of true positives and make stronger statements concerning the validity of the CPTQ.

Also, considerable thought must be given to the scoring procedure of the CPTQ in future investigations. We elected to exclude the data from 1 of the 3 subjects with a positive duplex Doppler ultrasound result because he did not recall if he avoided certain neck positions due to symptoms consistent with VBI. Given the low prevalence of positive duplex Doppler ultrasound findings in this pilot study, this was a very important decision. Originally, we considered his CPTQ to be a negative result, which markedly impacted the sensitivity and negative likelihood ratio. After more thought and group discussion, we decided to discard his data from analysis. Perhaps a better decision would have been to consider his CPTQ a positive result.

Also, subjects in this study were referred by their physicians for duplex Doppler ultrasound with suspicion of VBI. Inclusion of subjects from a cohort including asymptomatic people (no suspicion of VBI) would strengthen the screening ability of the CPTQ.

Lastly, in addition to duplex Doppler ultrasound, the use of vertebral artery testing by way of magnetic resonance angiography (MRA) as the gold standard test would also improve data collected on the diagnostic utility of the CPTQ.

Conclusion

The results of this case series study suggest that the CPTQ may prove to be a useful tool in the cervical spine pre-manipulative clinical decision-making process. Sensitivity, specificity, and likelihood ratios were all good to excellent; however; because the prevalence for a positive duplex Doppler ultrasound was extremely low, the results must be interpreted cautiously. Future research with larger sample sizes, asymptomatic subjects, and perhaps MRA as a gold standard test are needed to better interpret the validity of the CPTQ. ■

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